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ABSTRACT Advances in airdrop accuracy and employment strategy using the new Joint Precision Airdrop System (JPADS) now gives the Joint Force Commander (JFC) new precision engagement options, and will be especially useful during tomorrow's humanitarian relief operations. Internally steered Global Positioning System (GPS) guided parachutes now allow for airdrops with greater accuracy. JPADS has numerous applications across the Range Of Military Operations (ROMO), however this paper will focus on time-critical applications during humanitarian relief operations. Precision direct delivery promises to slash in-transit time, minimize hub and spoke shuttle operations, reduce handling costs and save lives early in a relief operation before larger forces can arrive on scene. This paper will describe JPADS and look at key attributes of its speed, precision and economy of force. Next, it will review the 2004 Pacific Tsunami as a limited case study, focusing on the DOD's response and if JPADS was available then, how it could have helped the JFC respond more rapidly and conclude the operation sooner. Additionally, it will draw conclusions from the author's research and finally make recommendations for the JFC.					
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**NAVAL WAR COLLEGE
Newport, R.I.**

**Will Precision Airdrop Capability Provide The Joint Force Commander
With The Rapid Response Required
For Tomorrow's Humanitarian Relief Operations?**

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

Advances in airdrop accuracy and employment strategy using the new Joint Precision Airdrop System (JPADS) now gives the Joint Force Commander (JFC) new precision engagement options, and will be especially useful during tomorrow's humanitarian relief operations. Internally steered Global Positioning System (GPS) guided parachutes now allow for airdrops with greater accuracy. JPADS has numerous applications across the Range Of Military Operations (ROMO), however this paper will focus on time-critical applications during humanitarian relief operations. Precision direct delivery promises to slash in-transit time, minimize hub and spoke shuttle operations, reduce handling costs and save lives early in a relief operation before larger forces can arrive on scene. This paper will describe JPADS and look at key attributes of its speed, precision and economy of force. Next, it will review the 2004 Pacific Tsunami as a limited case study, focusing on the DOD's response and if JPADS was available then, how it could have helped the JFC respond more rapidly and conclude the operation sooner. Additionally, it will draw conclusions from the author's research and finally make recommendations for the JFC.

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INTRODUCTION

...precision engagement is effects-based engagement that is relevant to all types of operations.

-- Joint Vision 2020

The United States (U.S.) military must be ready to rapidly respond to any tasking given it along the Range of Military Operations (ROMO) continuum.¹ One key and growing mission at the lower end of this continuum is humanitarian relief operations, as described in DOD Directive 5100.46, *Foreign Disaster Relief*, with additional guidance provided in Joint Pub 3-07.6, *Joint Tactics, Techniques, and Procedures for Foreign Humanitarian Assistance*, which states, "...relief roles for U.S. forces include immediate response to prevent loss of life and destruction of property..."² The operative words are "immediate response." The faster we can respond to a humanitarian crisis, the better.

The U.S. military leverages technology to respond quickly and accomplish its missions. Many technological improvements in recent years have come from the concept of "precision." Precision engagement is not a new concept; it was written into Joint Vision (JV) 2010 when published in 1996. JV 2010 stated: "Precision engagement will build on current U.S. advantages in delivery accuracy and low observable technologies. It will use a wide variety of means, including very accurate aerial deliveries or air drops, discriminate weapon strikes, and precise, all weather standoff capability."³ This reference to "very accurate aerial deliveries," envisioned over 11 years ago, is here now with JPADS. JV 2020 builds on this vision by stating, "...the capability to engage precisely allows the commander to shape the situation or battle space in order to achieve the desired effects while minimizing risk to friendly forces and contributing to the most effective use of resources."⁴

This paper will look at JPADS as it implements both JV 2010 and JV 2020's vision of precision engagement airdrop within the conduct of operational level humanitarian relief

operations a JFC may be tasked to support. This paper will not focus on the many detailed technical aspects of JPADS, differences in each of its components and subsystems, different suppliers, or specific tactics for its employment. But rather, this paper will maintain an operational level focus from the JFC's perspective. My thesis is JPADS, with its inherent speed, direct delivery capability and economy of force aspects, gives the JFC a vital new tool for dealing with tomorrow's humanitarian relief operations. This paper will endeavor to answer my research question: "Will precision airdrop capability provide the JFC with the rapid response required during tomorrow's humanitarian relief operations?"

WHAT IS THIS NEW JOINT PRECISION AIRDROP SYSTEM?

JPADS is the JDAM of precision vertical resupply.

-- Gen. Duncan J. McNabb, AMC Commander

Simply put, JPADS is the technological advancement to airdrop equipment and employment techniques that dramatically increase delivery accuracy. This greater accuracy is now achieved from higher altitude drops, as high as 25,000 feet up, to drop zones (DZs) as small as 100-meter in radius.⁵ Standard drop zone sizes vary, but for comparison, AFI 11-217, *Drop Zone and Landing Zone Operations*, 10 May 2007, Table 2.1, directs C-17s use 412 meters by 540 meters for single Container Delivery System (CDS) drops for altitudes up to 600 feet above ground level.⁶ Airdrops from higher altitudes, and/or with more than 1 CDS container, dramatically increase the size of the DZ required. This paper will focus specifically on GPS guided "steerable" chute systems, as they offer the greatest precision and safety potential for use in future humanitarian relief operations. In simplest terms, steerable JPADS uses a small onboard computer, receiving GPS signal updates throughout the descent,

to steer the load to a predetermined spot (identified by high precision coordinates) on the ground by means of steering lines attached to the parachute or parafoil.⁷ This system is a joint effort by primarily the Air Force and Army, but includes inputs from the Marines and Navy in the development of the parachutes, guidance systems, control units and software. Pictures showing a bundle and two different parachute types in-flight are included here:



Figure 1: JPADS Bundle and In-Flight Photos

(Photos by Army Natick Soldier Center)

JPADS, while still in development, has successfully demonstrated capability with 2,000 lb loads in both test and actual combat conditions in Afghanistan and Iraq. A 10,000 lb capacity version of JPADS is currently being tested, and the vision is one day for capability to drop loads as heavy as 60,000 pounds.⁸

WHY JPADS MATTERS DURING HUMANITARIAN RELIEF OPERATIONS

When the military gets a mission, it's awesome...others wouldn't do it as fast.

--David Binder, Reporter

Speed Is Of The Essence

In a disaster, the faster relief arrives the greater the chances of survival for the sick, injured and displaced. Some natural catastrophes, such as floods, drought, earthquakes,

tsunamis, hurricanes and typhoons, can impact large areas, compounding the challenge to the JFC to provide timely relief to those in need. Key infrastructure such as roads, bridges, sea and airports, railroads, etc., may be damaged or otherwise unserviceable, impeding the delivery and distribution of aid. Also, in today's global communications environment, with cell phone videos, digital pictures, videotape and camera footage able to be broadcast real-time or near real-time, graphic images of devastation and human suffering can increase the perceived pressure to "do something fast." Speeding relief as quickly as possible to the victims is often seen both as a moral obligation and a political necessity.

Precision Direct Delivery vs. Hub And Spoke

Hub and spoke distribution of relief supplies uses forward staging areas, or multiples of each, at which relief supplies flowing into the disaster area are collected. Supplies are then trans-loaded onto available aircraft, boats, helicopters or other vehicles/vessels, to then deliver where needed. The hub is the center of operations for that area, with multiple out and back trips made to meet the needs of the affected population. Operations at forward locations, close to or in the disaster area, can be challenging. Necessary equipment and personnel to run the operation from that point may first need to be sourced and delivered, and if not immediately available, relief operations may be delayed.

In the past, "traditional" airdrop was seldom utilized for humanitarian relief operations. It required, in terms of factor space, a suitable DZ, which usually did not exist at or close to the crisis area. Additionally, inserting a DZ survey team and developing a safe DZ would delay operations to such an extent that the time benefits of airdrops would be lost. Airdrop planners would have to ensure even a "tactical" DZ met minimum requirements for

length, width and distance from obstacles. DZ size is based on many factors, such as the aircraft's altitude, speed, type of parachutes used, winds, etc.⁹

However, JPADS now allows for low, medium and high altitude drops with much greater precision, and from up to 25,000 feet above the ground. High altitude drop capability can enable releases to multiple DZs on the same mission, in the same geographic area, irrespective of lighting or visibility conditions on the ground. Although the true accuracy of various JPADS models is classified, high precision GPS guidance cuts circular error dramatically compared to normal airdrop and cuts risk to personnel on the ground due to poor airdrop procedures and unplanned errors. Recent drop tests from high altitudes of the larger Dragonfly 10,000 lb class parafoil demonstrated an expected unclassified landing accuracy capability of approximately 150 meters.¹⁰ Lighter systems have demonstrated even more accuracy, but that number remains classified.¹¹ Another benefit of JPADS, because of its autonomous GPS guidance, is that it makes night airdrops possible, with ground personnel using night vision goggles for clearing with infrared lighting of the DZ and JPADS bundle.

Economy Of Force Implications

Airdrop by its very nature is a direct delivery method. Using current airdrop capable aircraft such as the C-130s and C-17s, direct delivery offers significant economies of force, as compared to traditional hub and spoke operations. JPADS can deliver relief supplies more rapidly and directly to those in need. Reducing or eliminating these intermediate or forward staging areas has many additional benefits, such as reduced security issues, less handling of supplies, a smaller force footprint, and a reserve capability should it be needed later. The JFC can then redirect scarce resources to other theater priorities, involved in or separate from, the on-going humanitarian relief operation.

An example scenario: A humanitarian crisis unfolds and the JFC determines JPADS will be used to start immediate relief operations. Working with the host nation, our country team and military liaisons identify “tactical” DZs suitable for JPADS airdrops and coordinate for our specially trained U.S. military forces (Combat Control Team, Special Tactics Squadron personnel, Special Forces, Drop Zone Support Team, etc.) to be inserted and linked up with host nation representatives. These forces on the ground provide the C2 link between our aircrews, host nation and the JTF to coordinate for safe and effective airdrops of relief supplies. The host nation military and/or civil authorities provide legitimacy, team and relief supply security, crowd control and follow on movement of supplies to those in need. Our on-site forces recover the JPADS systems and recycle them back for subsequent airdrop missions during extended operations. Of note, a huge public relations and Information Operations (IO) opportunity exists by inserting a Combat Camera, Civil Affairs (CA) of Public Affairs (PA) member in with our US military forces on the ground to document and disseminate the success of ongoing humanitarian airdrop operations.

Views of Others

For all its benefits, airdrop is not without some risk. However, risks associated with airdrops can be minimized in many ways. First, careful selection of the DZs can ensure both proximity to those in need and adequate safe separation from people on the ground. U.S. ground teams, with host nation support, can ensure a clear and safe DZ before aircrews drop relief, via radio and other communications. Also, although malfunctions are rare, planners can select a Computed Air Release Point that accounts for a possible parachute malfunction, so that if a pallet fails to get a good chute leaving the aircraft, it falls harmlessly over open water or an unoccupied area. Lastly, at any point airdrops present a delivery problem where

risk exceeds the benefit, its use can be reevaluated, adjustments made to delivery procedures or DZ selection, or a transition made to airland operations.

ANALYSIS OF THE PACIFIC TSUNAMI OF 2004 – Op UNIFIED ASSISTANCE

The devastation in the region defies comprehension. More than 150,000 lives are estimated to be lost, including 90,000 in Indonesia, alone. As many as 5 million people are thought to be homeless, or without food or shelter; thousands more are missing, and millions are vulnerable to disease.

-- President George W. Bush

A Disaster Of Biblical Proportions

On 26 December 2004 a massive 9.3 magnitude earthquake centered 100 miles off the coast of Indonesia triggered tsunami waves that struck the coastlines of nine Indian Ocean countries, with Indonesia, Sri Lanka, Thailand and India the hardest hit. The United Nations lists a total of 229,866 people lost, including 186,893 dead and 42,883 missing.¹² Hundreds of thousands were left homeless. Indonesia became the primary focus of humanitarian operations as 130,736 of the dead and 37,063 of the missing were attributed to Indonesia alone.¹³ Sri Lanka listed 35,322 dead, India 12,405 dead and Thailand 5,395 dead.¹⁴ The U.S. military's disaster response included assistance to Sri Lanka, Thailand, and others, however, this paper will focus only on the Indonesian relief effort, since it was the major relief focus in Op UNIFIED ASSISTANCE. Examining this one aspect of the relief effort as a case study will allow for a much clearer focus, first because it is so well documented, and second, as it was the DOD's primary focus in this crisis.

Synopsis of DOD's Response

Three days after the tsunami occurred, President Bush announced on 29 December 2004, that, "the Pentagon is 'dispatching a Marine expeditionary unit, the aircraft carrier [USS] Abraham Lincoln and the maritime preposition squadron from Guam to the area to

help with relief efforts.’”¹⁵ The USS Abraham Lincoln strike group departed Hong Kong on 29 December 2004 and arrived off the coast of Banda Aceh on 1 January 2005, and flew their first helicopter supply mission off the carrier on 2 January 2005.¹⁶ The Marine Expeditionary Strike Group (ESG), led by the amphibious assault ship USS Bonhomme Richard, with six accompanying vessels, operated its first relief mission on 10 January 2005, sending an air cushioned landing craft (LCAC) ashore with thirty pallets of food and water.¹⁷ The bulk of the on-site deliveries to needy survivors were first from ship stores to shore utilizing mostly helicopters and some LCACs. After 10 January 2005, a combination of ship stores and a growing source of relief supplies flowing into Banda Aceh airport provided the two main sources of aid. At its peak, as many as 58 helicopters were used to ferry relief supplies from various vessels to onshore locations and from forward points out to the needy.¹⁸ One critical problem helicopter crews faced was finding suitable landing zones given the treed terrain, tsunami debris and infrastructure damage caused by the tsunami.

The Air Force started relief operations first. Just 36 hours after reports of the disaster, six C-130s departed their U.S. bases in Japan, with relief supplies bound for Utapao, Thailand, arriving on 29 December 2004. The first C-130 airland relief missions were flown the following day.¹⁹ By 5 January 2005, Air Mobility Command had six C-5 aircraft staged out of Kadena Air Base (AB), Japan, and four C-17s staged out of Utapao.²⁰ By 11 January 2005 the airlift operation had grown dramatically, with a total of 21 C-130 aircraft on station at Utapao flying relief missions to various countries.²¹

Factors Of Time, Space and Force

The Pacific Ocean is a vast stretch of water, the largest ocean body, covering 65.3 million square miles in area, which equates to 32% of the earth’s surface area and is larger

than all the earth's land area combined.²² The distances that had to be traversed for the closest and best able Navy ships to arrive off the coast of Banda Aceh were considerable. The sea distance from Hong Kong to Banda Aceh is approximately 1,892 miles and even at 30 knots speed, the voyage took about three days. The sea distance from Guam to Banda Aceh is approximately 2,890 nautical miles, and at a speed of 25 knots that trip would take nearly five days to complete. These realities of factors time and space meant days would pass before U.S. Navy forces were in place off the coast of Indonesia.

To provide an air hub for supporting disaster relief operations, PACOM stood up Joint Task Force (JTF) -536, later renamed Combined Task Force (CTF) - 536, at Utapao, Thailand. Utapao was only 590 nautical miles from Banda Aceh, which offered relatively close proximity by air, a large runway and ramps, and sufficient facilities necessary to operate a large-scale relief effort using airlift aircraft.

How Might JPADS Have Helped, If Available Then?

In his book *Waves of Hope*, Mr. Bruce Elleman writes: "In the speed-versus-capability equation, speed will almost always win out in a humanitarian disaster response."²³ He goes on to say, "Although the Transportation Command efficiently deployed prepositioned ships and moved many supplies by sea, the cost was high. In the future, air delivery in combination with air drops would be more cost-effective."²⁴ Mr. Gordon Weiss, UNICEF's spokesperson for emergencies voiced great concern for reaching stranded survivors saying, "With bridges to coastal towns wiped out by the waves and many airstrips jammed, the U.S. Navy helicopters have so far proved to be the most important piece of American relief aid."²⁵ With respect to the extraordinary burden carried by these helicopter crews, Mr. Elleman summarized in his book, *Waves of Hope*, "Helicopter pilots and crews

were generally overworked and overstressed. Alternative delivery capabilities are clearly needed.”²⁶ Supporting this view were problems encountered with Banda Aceh airport, the only airport close to the heart of the relief operation. Besides very limited ramp space, poor weight bearing capacity and low throughput was the reality of unexpected closures. Twice during the relief operation Banda Aceh airport was closed to relief operations--once when a helicopter crashed while landing and a second time when a commercial B-737 ran into a water buffalo.²⁷ These accidents unfortunately slowed relief operations at the airport and took focus away from the humanitarian relief operation at that location.

These significant airfield limitations, and other insights gained in after action reports, show that safely, rapidly and efficiently distributing relief supplies during Op UNIFIED ASSISTANCE in and around Banda Aceh was difficult, slow and costly. Lessons learned like these show how JPADS could have been employed by the CTF commander, if available then, with greater speed, agility and cost effectiveness than using Navy and Marine helicopters alone. JPADS usage would have freed up many of these helicopters to perform other tasks needing attention, but were not immediately addressed due to the top priority of delivering food and water to the tsunami survivors.

Looking back at the actual aircraft deployment timeline, six C-130s flying out of Utapao, Thailand, could have theoretically commenced JPADS missions on 30 December 2004, just four days after the tsunami, and the four C-17s could have commenced airdrop operations on 5 January 2005. Flight plans show with approximately 590 nautical miles between Utapao and Banda Aceh, C-130 flights would take approximately 2.4 hours one way, C-17s would only take about 1.7 hours one way.²⁸ C-130 crews could conservatively run two round robin missions in a 16 hour tactical flight duty period,²⁹ while augmented C-

17 airdrop crews could fly three round robin missions each in an 18 hour tactical crew duty day.³⁰ C-130s could airdrop sixteen 2,000 lb bundles per mission or five 10,000 lb pallets and C-17s could airdrop thirty-two 2,000 lb bundles or eight of the larger size 10,000 lb pallets each mission.³¹ Theoretically, these C-130s could have provided approximately a low of 1.152M lbs and a high of 1.8M lbs of relief supplies over 3 days (depending on type of bundle/pallets configured) before the USS Lincoln strike group flew their first helicopter relief sortie on 2 January 2005. With four C-17s starting airdrop operations on 5 January 2005 to augment on-going C-130 operations, a low of 8.064M lbs and a high of 11.4M lbs of relief supplies could have been delivered before the USS Bonhomme Richard operated its first mission on 10 January 2005. (Note: For simplicity, these and other calculations made by the author, assumed a 100 percent mission success rate, and can be adjusted by whatever factor the JFC deems appropriate.)

Next, let us take a closer look at what could have been possible with an even earlier start to airdrop relief operations, based upon an assumption JPADS was available to the CTF commander, was planned for use from the start and on scene DZ/CCT teams could be inserted and linked up with host nation forces. Remember, the first six C-130s arrived 29 December 2004. If the four C-17s that joined the operation later had been tasked to arrive that same day from McChord AFB, WA, or Hickam AFB, HI, with airdrop crews, JPADS units and required support personnel with Combat Camera included, airdrop operations could have commenced as well on 30 December 2004. This would include six C-130s flying two airdrop missions each per day and four C-17s flying three airdrop missions each per day to the Banda Aceh area. The author estimates this would have provided 24 combined sorties a day over three days and airdropped approximately a low of 3.456M lbs and a high of 4.68M

lbs of relief supplies directly to where needed most, before the USS Lincoln flew its first helicopter relief flight on 2 January 2005 and approximately a low of 12.672M lbs and a high of 17.16M lbs before the Bonhomme Richard performed its first LCAC relief mission on 10 January 2005.

CONCLUSIONS

Precision engagement significantly contributes to successful operations.

-- Gen. Dennis J. Reimer

Although originally envisioned and designed for precision resupply to troops under combat conditions, JPADS clearly has great value today to the JFC in applications at the lower end of the ROMO spectrum, specifically in future humanitarian crisis relief operations. Time is always against the JFC to provide relief to the needy as fast as humanly possible. In looking back, and critically analyzing the historical account of the DOD relief effort in Indonesia following the 2004 Pacific Tsunami, one can clearly see significant delays in getting relief to the survivors. This delay was primarily due to factors of time and space. Simply put, it took days to get the closest U.S. naval forces into position off the Indonesian coast to begin relief operations. The USS Lincoln CSG flew its first helicopter relief sortie seven days after the disaster. The Marine's USS Bonhomme Richard ESG did not get its first relief mission ashore until 15 days after the tsunami struck. These unavoidable delays show the tremendous opportunity available to the JFC to get early relief literally "arriving from the heavens" by teaming with USAF airpower, using precision airdrops with JPADS.

We can look at this 2004 Pacific Tsunami case study and see that it represents but one possible example of a major humanitarian crisis that a JFC may face in the future. Viewed from an operational perspective, we can conclude that had the decision been made sooner to

deploy air assets in support of precision airdrops, C-130s and C-17s could have been sourced and deployed much more quickly than they actually were. With the first 12 hours of a 24-hour pre-departure crew rest waived, BRAVO alert crews could have launched out of C-130 airbases such as Kadena AB and/or Yokota AB, Japan, and C-17 airbases at Hickam AFB, Hawaii, or McChord AFB, Washington, just 12 hours after being ordered to deploy. Upon arriving Utao, Thailand, these crews could have been alerted to fly their first JPADS precision airdrop missions over Indonesia just 12 hours later given the requisite coordination and support. This rapid response time, combined with precision airdrop effects of immediacy and accuracy, gives the JFC today the precision capabilities originally envisioned in JV 2010 when published back in 1996.

Looking at economy of force, the Navy had 13 ships off Indonesian shores in just the USS Abraham Lincoln CSG and USS Bonhomme Richard ESG. There were 14 other Navy ships and Military Sealift Command vessels in the Area of Operations at some point as well, many of which could not operate close to shore due to the shallow water.³² The aircraft carrier USS Abraham Lincoln by itself was expensive to operate, costing \$6,000,000 a day, and by the time it finally departed Indonesian waters on 3 February 2005 it had been on station a total of 34 days.³³

The author contends the early use of JPADS could have provided a large cost savings through the synergistic effect of Air Force and Navy assets each doing what they do best, and simultaneously bringing the crisis to an earlier conclusion. The airdrop of relief supplies up until the time the Bonhomme Richard ESG arrived could have then allowed a significant portion of their helicopters and/or LCACs to then have been used for needs that went largely unmet until very late in the effort. These would have included medical evacuation of the

injured, movement of Indonesian forces and NGO/civil support teams, diplomatic shuttles, IO, CA and PA support, etc. As it happened, the vast majority of helicopters were tasked to shuttle primarily food and water. The earlier conclusion of the crisis could have returned the CSG and ESG, as well as the participating Air Force assets, back to the JFC for other operational needs, which is another way to look at economy of force.

In summary, my paper's thesis is that precision airdrop, a subset of precision engagement, can in fact provide the rapid response the JFC needs for tomorrow's humanitarian relief operations. This paper has also shown that technological advances in precision airdrop using JPADS, if available then, and deployed at the outset of relief operations, could have cut in-transit time of relief supplies by days, minimized helicopter hub and spoke shuttle operations, significantly reduced handling costs and brought the operation to closure sooner through the synergy of Navy and Air Force capabilities.

RECOMMENDATIONS

Faster is better when responding to human crises--this point was made clear in several Op UNIFIED ASSISTANCE after action reports. After critically analyzing these and other important lessons learned, and from conclusions reached in this research paper, the author makes the following recommendations:

First, that JFC planning staffs incorporate JPADS into their "precision engagement mindset" and considers JPADS as a viable option today when doing contingency and crisis action planning. Second, that the JFC ensures that JPADS trained/certified C-130 and/or C-17 aircrew member(s) and support planners either reside on their planning staffs or are immediately available to them via video teleconferencing to provide this key skill set. Third,

that JFCs consider JPADS a realistic “first use” option when responding to humanitarian crisis, especially in the critical first days, as the crises may be brought to an earlier conclusion with the synergistic effects of combining the best of all assets. This allows for economies of force by returning valuable assets sooner for other theater needs. Fourth, that C-130 and C-17 Air Force units tasked with airdrop missions ensure that priority is given to certifying and maintaining current and proficient JPADS aircrews. This prioritization will guarantee that whenever JFCs call for JPADS forces, they will be available and ready. Fifth, that JFC’s planners consider the composition of the drop zone support team to include Combat Camera and/or PA to capitalize on and document the “positive press” of ongoing operational airdrop successes. Lastly, that the Air Force and Army continue to fund, develop and field JPADS with greater weight capabilities than the current 10,000 lb model. Future humanitarian relief missions could benefit significantly from far fewer missions flown to deliver heavier loads of relief supplies per sortie. Fewer sorties will dramatically lower costs and deliver more relief faster.

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